



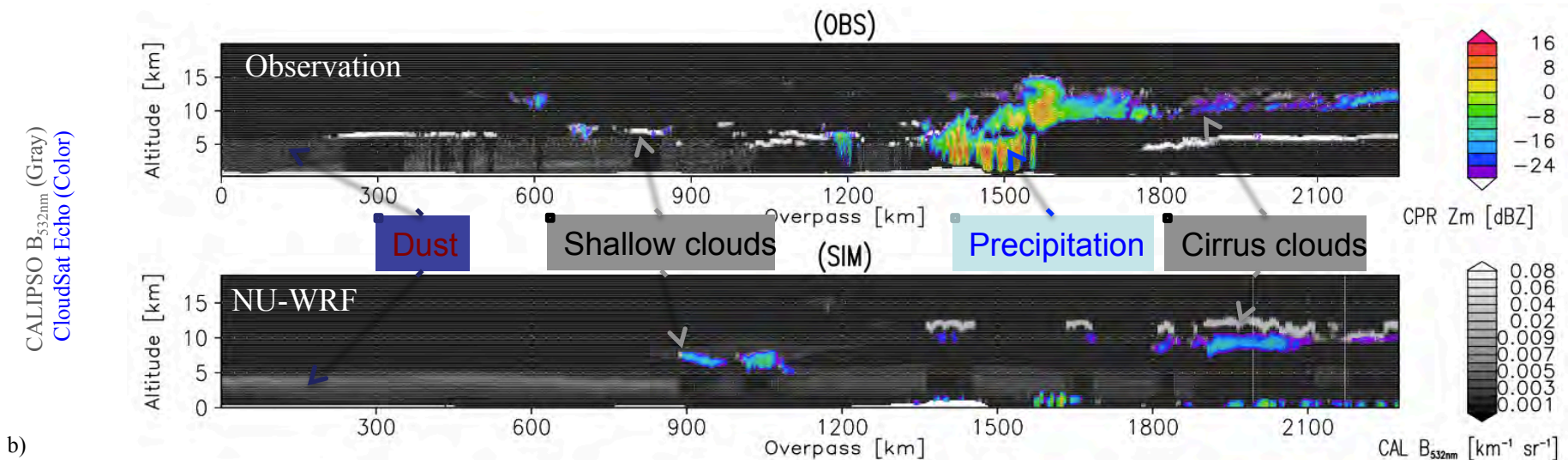
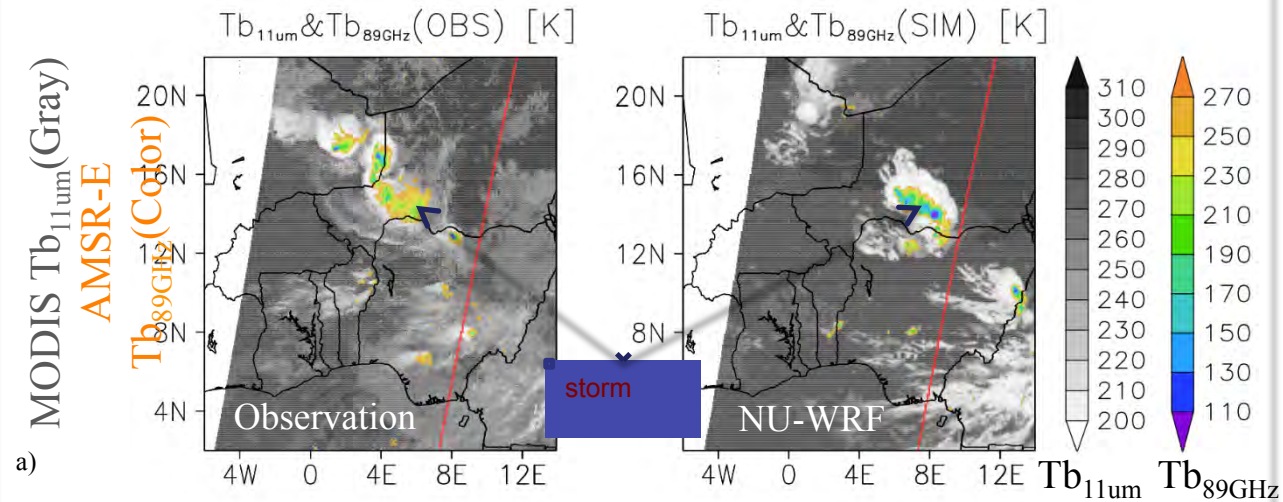
# A-Train Simulator Reveals Detailed Performance of NU-WRF

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NASA's multi-instrumental satellite simulator, G-SDSU, for the first time compares output from the regional Earth System model, NASA-Unified WRF, to multi-sensor signals from the A-Train satellites over the West Africa.





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## References:

Matsui, T., J. Santanello, J. J. Shi, W.-K. Tao, D. Wu, C. Peters-Lidard, E. Kemp, M. Chin, D. Starr, M. Sekiguchi, and F. Aires, (2014): Introducing Multi-Sensor Satellite Radiance-based Evaluation for Regional Earth System Modeling, *Journal of Geophysical Research*, 119, doi:10.1002/2013JD021424.

**Data Sources:** Aqua MODIS 12um brightness temperature is extracted from the MYD0222H product provided through LAADS web. Aqua/AMSR-E 85GHz microwave brightness temperature is extracted from the AE\_L2 product through NSIDC. CALIPSO 532nm backscatter is extracted from the CAL\_LID\_L1-ValStage1-V3-01 product through ASD. CloudSat 95GHz radar reflectivity is extracted from the 2B-GEOPROF product through CloudSat Data Center.

## Technical Description of Figures:

**Graphic a:** MODIS  $T_{b_{11\mu m}}$  overlaid with AMSR-E  $T_{b_{89GHz(V)}}$  (color) revealed detailed storm structure through a view of cloud (gray scale) and precipitation (color) signals. The same satellite signals were simulated from NASA-Unified WRF (NU-WRF) through the multi-instrumental simulator, Goddard Satellite Data Simulator Unite (G-SDSU).

**Graphic b:** CloudSat CPR reflectivity (color shade) and the CALIPSO CALIOP backscattering signals (gray shade) show detailed profiles of mineral dust and multi-layer cloud structure. Similar signals are simulated from NU-WRF via G-SDSU, which reveal strengths and weaknesses of fully coupled aerosol-cloud-precipitation-land simulation. The CloudSat satellite overpass is shown in Graphic a (red line).

**Scientific significance, societal relevance, and relationships to future missions:** Noble multi-sensor radiance-based evaluation for the first time reveals detailed aspects of fully coupled aerosol-land-cloud-precipitation processes. This multi-sensor satellite simulator, G-SDSU, and comprehensive evaluation framework creates a new benchmark for evaluation and development of a complex regional Earth System model, NASA-Unified WRF. G-SDSU and multi-instrumental evaluation framework can be applied to various current (A-Train, TRMM, GPM, Suomi NPP) and upcoming (SMAP, ACE) satellite missions.

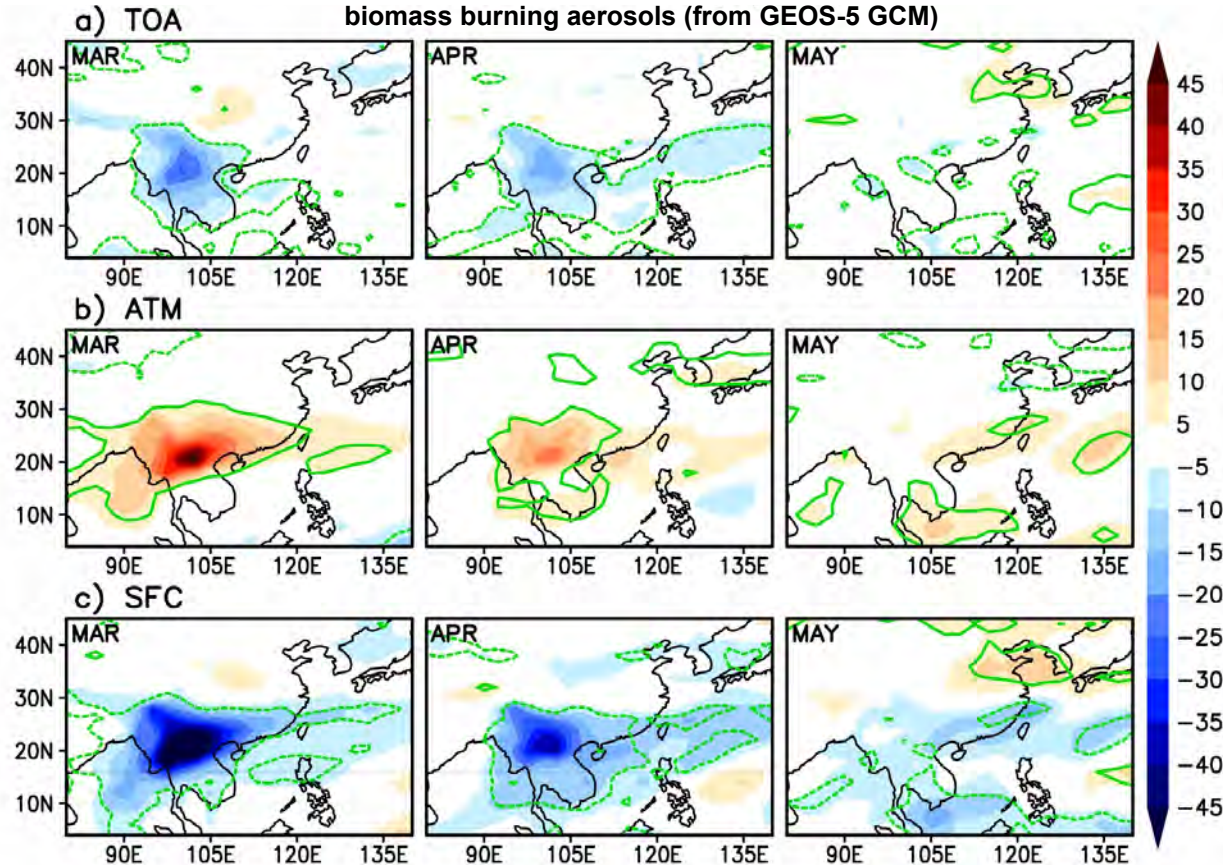




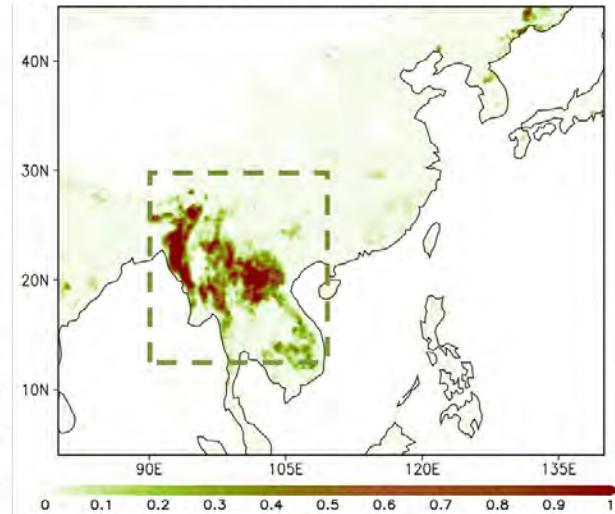
## Biomass burning aerosol affects pre-monsoon climate in SE Asia

D. Lee, L. Oreopoulos, Y. C. Sud, K.-M. Kim (Code 613), and W. K. Lau (Code 610AT) NASA/GSFC

Change in net radiative flux due to the collective effects of biomass burning aerosols (from GEOS-5 GCM)



Biomass burning emissions in Indochina during February-April



A properly equipped GCM like GSFC's GEOS-5 with our own McRAS cloud scheme can reveal a lot about both direct and indirect effects of aerosols and resulting feedbacks in heavily polluted regions of the world



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### References:

Lee, D., Sud, Y. C., Oreopoulos, L., Kim, K.-M., Lau, W. K., and Kang, I.-S.: Modeling the influences of aerosols on pre-monsoon circulation and rainfall over Southeast Asia, *Atmos. Chem. Phys.*, 14, 6853-6866, doi:10.5194/acp-14-6853, 2014.

**Data Sources:** The main data sources for the study are outputs from a series of experiments with a modified version of the GEOS-5 atmospheric GCM. Four sets (ensembles) of experiments, each consisting of ten members were conducted: (a) No biomass burning (BB) emissions over Indochina; (b) High BB emissions over Indochina (using 2007 data); (c) As in (a), but without direct aerosol radiative effects; (d) As in (b), but without direct aerosol radiative effects. Differences between these experiments allow us to evaluate the relative role of direct and indirect radiative effects. Also used in the study: GMAO's Quick Fire Emission Dataset (QFED) emission dataset to properly incorporate biomass burning emissions into GEOS-5; MODIS-Aqua Level-3 cloud and aerosol data and GPCC-1DD precipitation data for model validation.

### Technical Description of Figures:

**Multipanel Graph:** Net (=shortwave+longwave) radiative flux change between no BB aerosol and high BB aerosol GCM experiments for three months around around the climatological peak of BB emissions. The panels convey the collective effects of BB aerosols through direct and indirect (i.e., via cloud modification) radiative effects, as well as through feedbacks caused by circulation and surface meteorology changes. The flux changes are shown at the top-of-the-atmosphere (TOA) and surface (SFC) levels, as well as for the atmospheric column as a whole, with red indicating a warming influence and blue indicating a cooling influence.

**Map:** QFED biomass burning emission data. Organic Carbon February-March-April means were used for this figure, in units of  $\mu\text{g}/\text{m}^2/\text{s}$ . The area enclosed by the green dashed box is the area within which we control emissions in our various sets of GCM experiments.

**Scientific significance, societal relevance, and relationships to future missions:** Use of fossil fuels for ever-growing energy demands, particularly in developing countries, has led to increased concentrations of aerosol-laden combustion by-products. Some estimates suggest that aerosols over India have been increasing at the rate of 2-4% per year over the last three decades resulting in doubled aerosol optical depth in India's lower atmosphere, with similar changes expected over neighboring regions such as Southeast Asia. Biomass burning is an age-old method of disposing agricultural trash and in SE Asia occurs primarily during the spring season, February-March-April. It has been a widespread belief, supported by several studies, that such massive injections of BB aerosols must have climatic effects because of their interactions with solar radiation and their effects on clouds and precipitation, especially during the pre-monsoon period that follows the season of peak emissions. Using observations to untangle the aerosol effects is quite challenging, so modeling studies where conditions can be controlled have the potential to not only reveal interaction mechanisms that are not obvious, but also steer observational analyses in the right directions. Our study demonstrates that a breakdown of the relative importance of direct/indirect effects and feedbacks may be feasible, but requires a properly equipped GCM with realistic aerosol and cloud properties and proper parameterizations of cloud modification by aerosols. GSFC's efforts to improve such GCM capabilities should therefore continue. At the same time it is important that future observations from satellites are of the quality required for accurate retrievals of cloud microphysical properties.

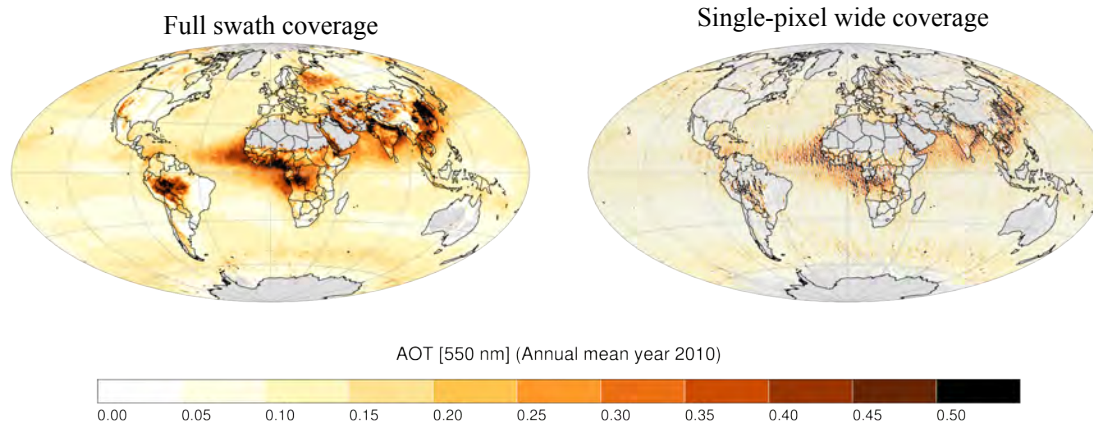
# Impact of satellite viewing-swath width on global and regional aerosol optical thickness statistics and trends

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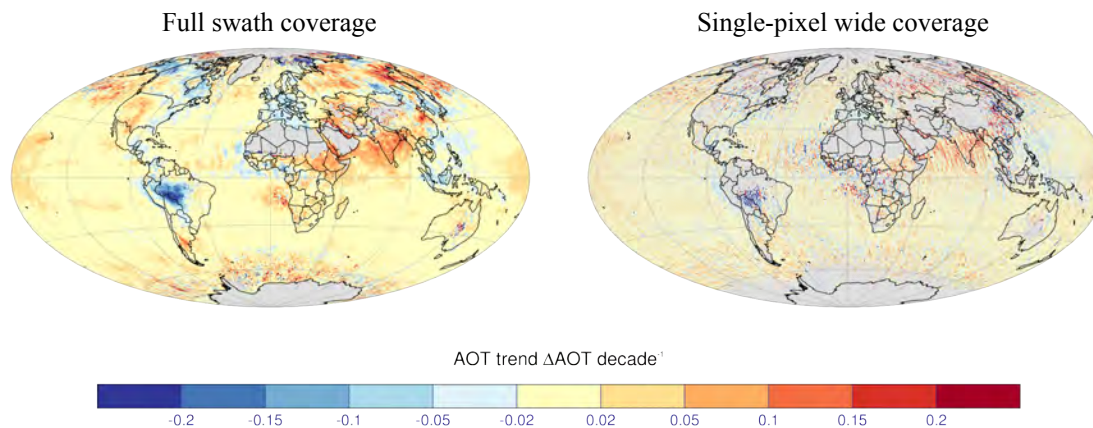
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*Spatial coverage is an important design consideration for future space-based aerosol remote sensing measurements. We explored the impact of reduced spatial coverage on the statistics of the amount of aerosol detected, as well as on our ability to confidently measure how aerosol loading is changing in time.*

Aerosol loading (the aerosol optical thickness, or AOT) from MODIS Aqua for the year 2010



Decadal trend in aerosol loading for the MODIS Aqua instrument over the years 2003 - 2012







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## References:

Colarco, P. R., Kahn, R. A., Remer, L. A. and Levy, R. C.: Impact of satellite viewing-swath width on global and regional aerosol optical thickness statistics and trends, *Atmos. Meas. Tech.*, 7(7), 2313–2335, doi:10.5194/amt-7-2313-2014 (2014).

**Data Sources:** Data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments onboard the Terra and Aqua spacecraft were used in this study, as were results from the NASA Goddard Earth Observing System (GEOS-5) Earth system model. The full swath of MODIS Aqua aerosol observations were sub-sampled along candidate narrower and single-pixel wide swaths in order to investigate the impact of reduced spatial coverage on the statistics of aerosol loading (i.e., aerosol optical thickness, or AOT) and trends in aerosols. AOT data derived from both MODIS instruments were also assimilated into the GEOS-5 simulation in order to correct errors in the simulated aerosol fields.

## Technical Description of Figures:

**Figure 1:** Top panel shows the year 2010 annual average AOT derived from the MODIS Aqua observations. The left portion shows the annual average AOT if the full swath of the MODIS observations is used. The right panel shows the annual average AOT if only a subset of the observations, along a single-pixel wide stripe of the full swath observations, is used. Gaps in the observations and different magnitudes of the AOT at certain geographic locations are evident when the single-pixel wide observations are compared to the full swath observations. Bottom panel shows the computed decadal (2003 - 2012) trend in aerosol loading (i.e., change in AOT per decade) for the full swath (left) and single-pixel wide swath (right) viewing choices. Because of the reduced spatial coverage of the single-pixel wide sampling, the trends shown for that case are not found to be statistically significant at sub-continental spatial scales, whereas regions of statistically significant trends are more pronounced for the full swath viewing conditions (not shown).

**Scientific significance:** There remain considerable uncertainties in the climate impacts of atmospheric aerosols—airborne particulates that come from natural and man-made processes. Reducing those uncertainties, and so better understanding the importance of aerosols as a forcing agent in the climate system, requires improvements in our abilities to observe and model aerosols. Because aerosols are relatively short-lived in the atmosphere and have spatially and temporally variable sources and distributions in the atmosphere, a key component of our ability to monitor and detect changes in aerosol loading comes from satellite observations. One of the questions to ask as we consider future satellite mission concepts is how broad our spatial coverage needs to be. Often, there are trade-offs in mission design; for example, we might choose to sacrifice spatial coverage in favor of a better measurement along the narrower swath that we choose to observe. Our study was aimed at understanding how our estimate of aerosol loading, as well as our ability to confidently detect changes in aerosol loading, are impacted if we reduce the spatial coverage of our satellite observing system.

**Relevance for future science and relationship to Decadal Survey:** Our study was motivated by our participation in the Decadal Survey Aerosol-Clouds-Ecosystems (ACE) science working group. We wanted to provide input to the ACE study group that would help in defining design requirements. We found that while narrowing the spatial coverage of a satellite observing system has minimal impact on our ability to monitor the global, annual mean aerosol loading, it will have a significant impact on our ability to monitor aerosol loading at regional and seasonal scales. Furthermore, reduced spatial coverage hinders our ability to confidently detect trends in aerosol loading at smaller than continental scales.